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Resistivity studies of lignocaine complexes

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Abstract : Temperature variation of the resistivities of metal complexes of lignocaine hydrochloride(LH) has been studied. The complexes studied are dichloro dinitro oxouranium lignocaine (UOL), lignocaine tetrachlorocuprate (CUL), lignocaine tetracobaltate (COL) and lignocaine hydrochloride platinum chloride (PTL). All the complexes show semiconducting behaviour with varying degree. The resistance of the complexes vary over a wide range of a few kilo ohms to giga ohms. The difference in the resistivities of the materials can be understood in terms of the molecular packing in the crystalline state.

Keywords Lignocaine complexes, organic semiconductors, resistivity, temperature variation.

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The observation of electron transport in organic solids started around the year 1950. Vartanyan [1] made observations of photo conduction with thin films of dyes, tripaflavine and crystal violet deposited onto a quartz plate from alcohol solutions. Akamatu and Inokuchi [2] have reported the existence of electronic conduction in polycyclic aromatic compounds. The conductivities of the complexes are indicators of the degree of polarizabilities of the components. Crystalline complexes have higher conductivities than other organic solids. The resistance of the complexes are, generally, found to vary as per the following equation :

$$R = R_o \exp(-\Delta E/kT), \tag{1}$$

where ΔE is the activation energy.

Lignocaine hydrochloride, 2-(diethylamine)-N-(2,6-dimethyl phenyl) acetamide hydrochloride, an important acetamide derivative is also known as lidocaine, gescicaine and xylocaine. It is one of the most common local anaesthetics and anti-arrhythmic drug. Owing to the importance of lignocaine, we have undertaken the study of a series of complexes of LH

with various metals. We report here the resistivity measurements of the complexes UOL, CUL, COL and PTL.

Good single crystals were used for the purposes of dc resistance measurement as a function of temperature. The experimental setup consisted of a heating chamber, temperature controller, variac and a digital multimeter. Two probe technique was employed for resistance measurement. The resistance was measured with a Keithley 195A digital multimeter having an accuracy of 0.06% of the reading and a resolution of 100Ω. The temperature of the heating chamber was measured using a Cromel-Alumel thermocouple connected to the temperature controller which had an accuracy of 1% of the reading. Care was exercised to maintain the temperature of the samples below their melting points.

The resistance of the complexes range between 10^3–10^{12} ohms. The resistance of the complexes of CUL, COL and PTL are found to vary as per eq. (1). The resistance of UOL varies as per eq. (1) in two temperature ranges. The log$R$ *vs* $1/T$ plots are shown in Figures 1 and 2. The rate of fall of resistance with temperature is highest for PTL and lowest for UOL.

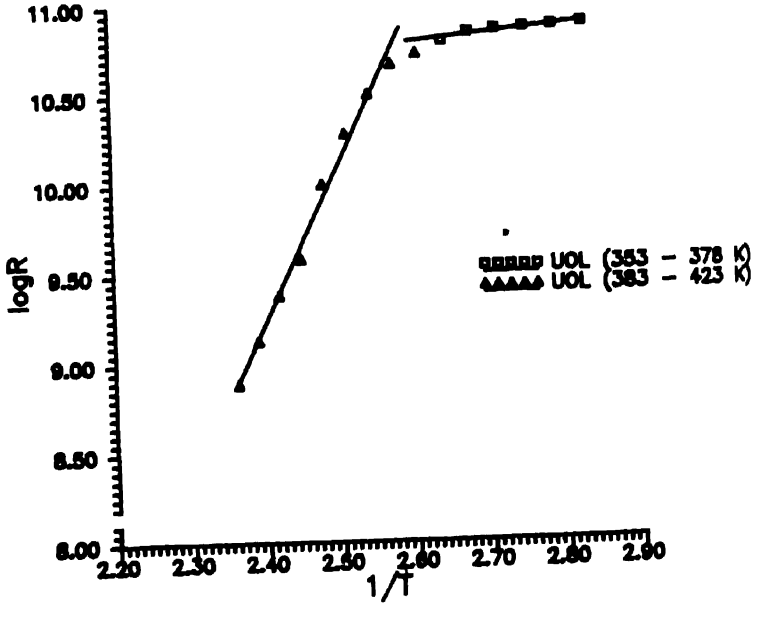

Figure 1. Variation of resistance of UOL with temperature.

As is evident from the graphs, the materials under study are semiconducting in nature. The activation energies of the complexes are as given in Table 1.

The activation energies show a wide variation for the materials under study, spanning a range of values from 0.08 – 2.63 eV. The variation in the fall of resistance of the complexes is quite common which is explained in terms of the nature of the stacking of the molecules [3]. The values obtained for the complexes under study are in conformity with the values

obtained for the complexes of lignocaine with chromium chloride, copper nitrate and manganese chloride [4]. The values are of the same order as those of the complexes of

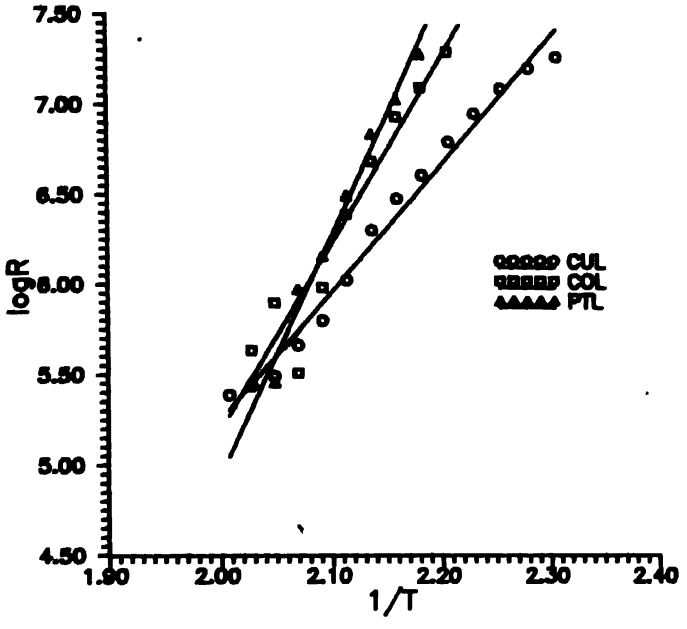

Figure 2. Variation of resistance with temperature for CUL, COL and PTL

diphenyl pyraline hydrochloride [5,6]. The structures of the complexes of UOL [7], CUL [8], COL [9] and PTL [10] have been determined. The structure of CUL complex is

Table 1. Activation energies of the complexes studied

Complex	Slope of the log *R vs* 1/*T* plot	Correlation coefficient	Activation energy (eV)
UOL (353–378 K)	423 63	0.85	0 08
UOL (383–423 K)	8699 35	0.99	1.73
CUL	7087 56	0 98	1.41
COL	10295.40	0 92	2.04
PTL	13228 80	0 98	2.63

shown in Figure 3 [8]. The complexes UOL, CUL and COL do not show alternate stacking of the donors whereas the packing of PTL shows stacked donor-acceptor layers. It is also found that the number of intermolecular contacts and the degree of overlap of the molecules have a bearing on the conductivity [11-13]. The packing of the UOL molecules show a large number of interchain contacts, whereas the packing of CUL and COL molecules shows poor

stacking either of ligands or metal atoms [7-9]. Due to the large variation in the orientations of the molecules within the stacks, one cannot draw definite conclusions about the effect of these on the properties of the materials [14,15].

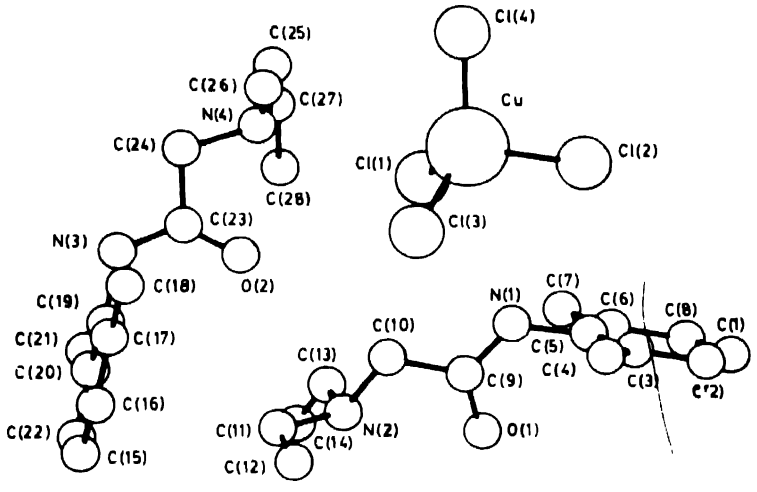

Figure 3. Projection of the molecule of lignocaine tetrochlorocuprate on the best plane

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